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OBSERVATIONS ON THE EFFECT OF WATER-RAKING ON THE KEEPING QUALITY OF CRANBERRIES

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The practice of "water-raking" cranberries—that is, of flooding the bog and "raking" or "scooping" up the berries as they float on or near the surface of the water—is prevalent among many of the Wisconsin cranberry growers. This practice has raised the question of the effect of the more or less prolonged submergence on the keeping quality of the berries. It is often asserted that "water-raked" cranberries do not keep well. Many growers believe that even the flooding of a bog to prevent frost injury to the ripening fruit has a detrimental effect on their keeping quality. On the other hand, it is claimed by others that water-raked berries keep as well as dry-raked if properly handled.

No previous work on water-raking in relation to the keeping quality of cranberries has been done. Accordingly a series of observations was made to secure evidence as to the occurrence of injury which may be properly attributed to water-raking, the causes of injury, the conditions under which it may occur, and how it may be eliminated or reduced.

The work was done in Wisconsin during the cranberry-picking seasons of the years 1918 and 1919. In 1918 field observations were followed by counting tests of berries in storage at Chicago, Ill., and Minneapolis, Minn.

OBSERVATIONS ON THE KEEPING QUALITY OF DRY- AND WATER-RAKED CRANBERRIES IN STORAGE

In attempting to secure some indication as to the effect of water-raking on the keeping quality of cranberries in storage, a number of counting tests have been made on berries from various sources. In these tests as many data as possible have been secured as to the previous treatment of the berries which might affect their keeping quality. Such tests, naturally, do not have the value of experimental results, since the lots of berries from which these counts have been made represent different growing conditions and different treatments during harvest and subsequently until their arrival at the warehouse where the counts were made. However, the figures are of some value as "indicators." In some instances in which lots of dry- and water-raked berries have been taken from the same marsh and have been kept under essentially the same conditions since harvest, the results are nearly as valuable as if obtained from definitely planned

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experiments. Some figures obtained from counts on miscellaneous lots are given in table 1.

TABLE 1. *The Percentage of Sound and Soft Berries in Miscellaneous Lots of Cranberries in Storage at Chicago during the Autumn of 1918*

Variety	Date Examined	Method of Picking	Total No. Counted	Sound		Soft	
				Num-ber	Per-centage	Num-ber	Per-centage
Metallic Bell.....	Oct. 18	Water-raked	705	672	95.3	33	4.7
Metallic Bell.....	" 18	" "	494	428	86.7	66	13.3
Metallic Bell.....	" 18	" "	603	524	86.9	79	13.1
Bennet Jumbo....	Nov. 23	" "	622	556	89.4	66	10.6
Prolific.....	" 23	Dry-raked	436	369	82.6	62	14.2
Prolific.....	" 25	" "	539	455	84.4	84	15.6
Juneau.....	" 25	" "	681	592	86.9	76	11.2
Metallic Bell.....	" 25	Water-raked	495	406	82.0	89	18.0
Metallic Bell.....	" 25	" "	646	507	78.5	139	21.5
Bennet Jumbo....	" 25	" "	520	439	84.4	81	15.6
Bennet Jumbo....	" 26	Dry-raked	455	406	89.2	49	10.8
Bennet Jumbo....	" 26	" "	391	351	89.8	40	10.2
Juneau.....	" 26	" "	717	579	80.8	138	19.2
McFarlin's(?)....	" 26	" "	714	537	75.2	177	24.8

On examination of the figures in table 1, it is evident that no greater difference is to be found between the keeping quality of dry- and water-raked berries than may be found between certain lots picked by the same method. This is to be expected, as the various lots are not comparable. Differences in the conditions under which the berries were grown, in methods of drying, varying weather conditions at different times during the drying period, and differences in methods of handling or in conditions of storage before shipment might make as great a difference in keeping quality as would be found between water- and dry-raked berries grown and handled under otherwise similar conditions.

It is apparent for the reasons indicated that conclusions as to the effect of water-raking on the keeping quality of cranberries are not warranted unless comparison is made between dry- and water-raked berries of the same variety from the same bog handled and stored under as nearly identical conditions as is possible. Such a comparison is made in table 2.

These berries were examined within a week or ten days after their arrival in Chicago, so that the total time that had elapsed since they were put in barrels was probably not more than three weeks. One sample from a barrel was taken in each case. The results here indicate clearly a superiority in the keeping quality of the dry-raked berries. The average loss for the latter is 8.4 percent, while for the water-raked berries it is 16.5 percent. The length of time that the berries were kept in water is not definitely known in all cases. The Early Blacks were flooded at night and raked the next day. Unfortunately none of these were dry-raked, so that no comparison can be made in their case except to note that they apparently have

been injured somewhat less than the water-raked Metallic Bell. Some of the latter were held in water two days before raking. As counts on two barrels showed 18.1 and 21.1 percent of soft berries, it is probable that these were some which had been under prolonged flooding.

TABLE 2. *A Comparison of the Keeping Quality of Dry-raked and Water-raked Cranberries in Storage*

Variety	Method of Picking	Date Examined	Total No. Counted	Sound		Soft	
				Num-ber	Per-centage	Num-ber	Per-centage
Metallic Bell.....	Water-raked	Nov. 27	536	439	81.9	97	18.1
Metallic Bell.....	" "	" 27	555	438	78.9	117	21.1
Metallic Bell.....	Dry-raked	" 27	318	284	89.3	34	10.7
Metallic Bell.....	" "	" 27	282	266	94.3	16	5.7
Early Black.....	Water-raked	" 27	540	465	86.1	75	13.9
Early Black.....	" "	Dec. 2	605	527	87.1	78	12.9
Metallic Bell.....	" "	" 3	703	598	85.1	105	14.9
Metallic Bell.....	" "	" 3	574	491	85.5	83	14.5
Metallic Bell.....	" "	" 3	608	525	86.3	83	13.7
Metallic Bell.....	Dry-raked	" 3	582	522	89.7	60	10.3
Metallic Bell.....	" "	" 3	651	590	90.6	61	9.4
Metallic Bell.....	" "	" 3	510	485	95.1	25	4.5
Metallic Bell.....	" "	" 3	590	540	91.5	50	8.5
Early Blackl.....	Water-raked	" 3	696	595	85.5	101	14.5

Three other barrels of cranberries were also examined, one hand-picked and two water-raked. Of the latter, one was raked early while the berries were only slightly colored. The second was raked after the berries had become fully colored. The results are given in table 3.

TABLE 3. *A Comparison of the Keeping Quality of Hand-picked (dry) and of Water-raked Partly Colored (immature) and Fully Colored Metallic Bell Berries in Storage at Chicago, Ill., in 1918*

Method of Picking	Date Examined	Total No. Counted	Sound		Soft	
			Number	Percentage	Number	Percentage
Water-raked immature.....	Oct. 27	511	476	93.2	35	6.8
Water-raked mature.....	" 27	499	466	93.4	33	6.6
Hand-picked.....	" 27	439	421	95.9	18	4.1
Water-raked immature.....	Dec. 7	3,092	1,626	52.4	1,566	47.6
Water-raked mature.....	" 7	3,174	2,147	68.2	1,027	31.8
Hand-picked.....	" 7	2,695	2,398	89.2	297	10.8

In this instance counts were made when the barrels first arrived at the Chicago warehouse and again about five weeks later. In the first examination only a single sample was taken from each barrel. On the later examination, however, samples were taken from the top, middle, and bottom of each barrel and the results were averaged. It is to be noticed that even on the first count the water-raked berries showed decidedly more soft

berries than did the hand- (dry-) picked. The early-raked (partly colored) berries also showed a slightly higher percentage of soft berries than did those which were raked later after the berries were fully colored.

After a month in storage the differences were very apparent. The hand-picked berries had kept far better than the water-raked, and of the latter the dark berries had kept better than the light-colored ones. The better keeping quality of the mature, dark-colored berries may be accounted for by the fact that the respiratory activity of fruits decreases as the fruit ripens. Hence their oxygen requirement is less, and they suffer less injury through submergence than the less ripe berries, which have a higher oxygen requirement.

Counting tests were also made on several varieties of cranberries in storage at Minneapolis, Minn., during the winter of 1918. These berries were grown on the same bog and received essentially the same treatment after picking. The results are given in table 4.

TABLE 4. *A Comparison of the Keeping Quality of Dry- (hand-) picked and Water-raked Cranberries in Storage at Minneapolis, Minn., in 1918*

Variety	Method of Picking	Date Examined	Total Weight of Berries Examined	Sound		Soft	
				Weight	Percentage	Weight	Percentage
Searles Jumbo .	Water-raked ²	Nov. 12	70 oz.	50 oz.	71.4 ⁴	20 oz.	28.6 ⁴
Searles Jumbo .	" "	" 12	71 oz.	50 oz.	70.4 ⁵	21 oz.	29.6 ⁵
Searles Jumbo .	" "	" 12	67.5 oz.	55 oz.	81.5	12.5 oz.	18.5
Prolific	" "	" 15	58 oz.	43 oz.	74.2	15 oz.	25.8
Bennet Jumbo .	" "	" 15	66 oz.	48 oz.	72.7	18 oz.	27.3
Howes	" "	" 5	66 oz.	60 oz.	90.9	6 oz.	9.1
Early Black	" "	" 15	68 oz.	57 oz.	83.8	11 oz.	16.2
Searles Jumbo .	" " ²	Dec. 9	1,689 g.	770 g.	45.6	919 g.	54.4
Searles Jumbo .	" " ³	" 9	1,698 g.	1,063 g.	62.6	635 g.	37.4
Searles Jumbo .	" " ³	" 9	1,858 g.	1,280 g.	68.9	578 g.	31.3
Searles Jumbo .	" "	" 9	1,921 g.	1,396.5 g.	72.7	524.5 g.	27.2
Searles Jumbo .	" "	" 9	1,979 g.	1,694 g.	85.6	285 g.	14.4
Searles Jumbo .	" "	" 10	1,894 g.	1,405 g.	74.2	489 g.	25.8
Searles Jumbo .	" "	" 10	1,832 g.	1,422 g.	77.6	410 g.	22.4
Searles Jumbo .	Dry-picked	" 10	2,151 g.	1,947 g.	90.5	204 g.	9.5
Searles Jumbo .	" "	" 10	1,944 g.	1,689 g.	86.9	255 g.	13.1
Searles Jumbo .	" "	" 10	2,050 g.	1,850 g.	90.2	200 g.	9.8
Searles Jumbo .	" "	" 11	2,030 g.	1,850 g.	91.1	180 g.	8.9
Searles Jumbo .	" "	" 11	1,691 g.	1,532 g.	90.6	159 g.	9.4
Searles Jumbo .	" "	" 11	1,931 g.	1,778 g.	92.1	153 g.	7.9
Howes	Water-raked	" 11	1,893 g.	1,629 g.	86.1	264 g.	13.9
Howes	" "	" 11	1,959 g.	1,694 g.	86.5	265 g.	13.5
Howes	" "	" 11	1,846 g.	1,587 g.	86.0	259 g.	14.0
Howes	" "	" 11	1,963 g.	1,733 g.	88.3	230 g.	11.7

² Picked early, berries not well colored, water held 2½ days, stored in barrels.

³ Picked late, berries fully colored, water held 3 to 5 days, stored in barrels.

⁴ From top of barrel.

⁵ From center of barrel.

It may be seen by comparing the percentage of spoilage of water-raked

berries from the same bog, stored under the same conditions, as shown in tables 1 and 4, that the extent of injury is not the same in all varieties. In table 1, comparing Metallic Bell and Bennet Jumbo, which were from the same grower and were examined at essentially the same time (November 23-25), it is seen that the Metallic Bell shows a greater percentage of spoilage than the Bennet Jumbo. A similar relation is indicated by the comparison of water-raked varieties examined at Minneapolis November 12-15 and also between Searles Jumbo and Howes examined December 9-11. In this case the test was a severe one, as the berries were under water from three to five days before being raked. Prolific and Bennet Jumbo were injured worse than Searles Jumbo, Howes least of all, and Early Black about the same as Searles Jumbo.

CAUSES OF SPOILAGE IN WATER-RAKED CRANBERRIES

The spoilage of water-raked cranberries is due to two causes: fungous rots and smothering. The fungi which are important in causing storage rots are present on the bogs and may gain entrance into the berries before they are picked. Having gained entrance, the fungus may remain inactive indefinitely, at least without any external manifestation of its presence, and then become active and result in the decay of the berry. It is possible also that infection may occur under certain conditions after the berries are picked. However this may be, it is well known that methods of handling and of storage are very important in determining the amount of spoilage.

Spoilage from smothering is not confined to water-raked berries. It may be caused by various conditions, as indicated by Shear and associates (4, p. 4). With the exception of smothering as a result of flooding, the conditions under which it occurs are the same for water-raked as for dry-raked berries. The length of time during which cranberries may be kept flooded without injury by smothering is determined by the oxygen content of the water and by the rate of respiration of the berries. The oxygen content of the water used for flooding Wisconsin marshes has been found to be generally low. For this reason injury by flooding is particularly apt to occur unless care is taken to prevent it. The causes of this oxygen deficiency will not be considered here. Some of the factors concerned have been indicated elsewhere (1) and will be treated more fully in another paper.

With reference to the rate of respiration, attention may be called to the age of the berries at the time of flooding in relation to the degree of injury sustained. Green cranberries are the first to suffer from smothering when flooded. This is well illustrated by the percentage of spoilage in partly colored and in fully colored water-raked berries as shown in table 3. A similar difference in the extent of injury between early-raked (not fully colored) and late-raked (fully colored) berries in storage at Minneapolis is shown in table 4. In order to avoid any effect of difference in treatment after picking, the comparison is limited to Searles Jumbo examined De-

cember 9. These berries were stored in barrels under the same conditions. The early-picked berries were in water not over $2\frac{1}{2}$ days; the late-picked were in water 3-5 days. Notwithstanding this, the late-picked berries show a lower percentage of spoilage than the early-picked. Two barrels of the former showed 31.1 and 37.4 percent while the latter showed 54.4 percent of spoilage. The greater injury in the case of the early-picked berries is probably due to the higher respiration rate of these berries.

METHODS OF DRYING IN RELATION TO SPOILAGE

A large, if not the greater, part of the loss in cranberries after harvest is due to rot-producing fungi. The conditions favoring their development are not well understood. The prevalence of these fungi varies in different seasons, with different varieties, on different bogs, and even on different parts of the same bog. There seems to be a definite correlation with weather conditions, particularly with humidity. Because of the possibility of infection by fungi whenever sufficient moisture is present, water-raking may cause greater loss by decay of the berries after harvest than would be the case if they were dry-raked. Any difference in this respect between water-raked and dry-raked berries depends to some extent upon weather conditions. If there is danger of frost, the bog must be flooded whether the berries are to be water-raked or dry-raked. The only difference is that for the latter the water is withdrawn and the vines are allowed to become completely dry before the berries are raked. In this way complete drying is insured. In water-raking this may not be true, even with good drying conditions, unless care is taken. With poor drying conditions the berries may remain several days before becoming sufficiently dry to be taken into the storage house. In some instances the berries may be placed in drying crates and be taken at once into the storage house instead of being left outside to dry as is usual. In either case the period during which conditions are favorable for infection by fungi is greatly lengthened, and greater loss by fruit rots results.

STORAGE CONDITIONS IN RELATION TO SPOILAGE

This problem has been discussed by Shear and associates (4). Since all conditions which apply to dry-raked berries apply also to water-raked, it need not be treated at length here. The importance of keeping the berries dry during storage and in shipping is pointed out by these writers (p. 8). They also state that cranberries should be picked dry, as does Franklin (2, p. 216). None of the experiments described, however, show that picking wet is the cause of spoilage. The berries were not dried after picking but were placed in boxes and stored in a wet condition. Under these circumstances the increased spoilage must be attributed, largely at least, to increased infection by fungi as a result of slow or incomplete drying. This is confirmed by the following statement of Franklin (p. 203):

The averages of percentages in the table show that the berries stored wet rotted more than those stored dry in both series of tests. The wet berries in the second series were more nearly dry when picked than were those of the first series, this apparently accounting for the smaller difference in the average amounts of rot that developed in the two lots of Howes fruit. The wet berries left on the bog were perhaps dried a good deal, as compared with those housed at once, by the high temperatures and free circulation of the open air, this perhaps explaining their better keeping.

The necessity of ventilation during storage is indicated by a comparison of the keeping quality of water-raked berries stored in barrels and in boxes at Minneapolis. The following figures are taken from table 4. Two barrels of late-picked Searles Jumbo examined December 9 showed 31.1 and 37.4 percent of spoilage respectively. The average of the two barrels is 34.25 percent. On the same day and on the day following the examination of four lots of the same variety, late-picked, stored in boxes, showed an average spoilage of 22.5 percent. These lots were all of the same variety, were all late-picked, were held in water for the same length of time, and were stored under similar conditions except as to the kind of container in which they were packed. Therefore the difference in keeping quality must be attributed to the tightness of the barrels, which excluded oxygen sufficiently to cause smothering of the berries. A careful separation of smothered and fungus-rotted berries would probably have confirmed this view. Lack of time and facilities, however, prevented this from being done.

Whether or not there is a greater tendency of water-raked than of dry-raked berries to become smothered in barrels during storage cannot be stated at this time. It is possible, however, that the holding of water on the berries at picking time, especially if the water is held for a considerable period, interferes permanently with the normal respiration of the berries. This may have the effect of "weakening" the berries, or of producing a tendency to collapse earlier than would otherwise happen when subjected to somewhat unfavorable storage conditions. It has been demonstrated by Hill (3, p. 395) that peaches from which oxygen has been excluded for a few days were unable to regain their normal rate of respiration. He states that "this would indicate a permanent injury to the protoplasm or to some of the enzymes due to insufficient oxygen."

PRECAUTIONS TO BE OBSERVED IN WATER-RAKING

In view of the preceding discussion it may be said that water-raking of cranberries, without serious injury to their keeping quality, is possible under favorable conditions. Since most of the conditions are not controllable, the possibilities of injury by water-raking are greater than in dry-raking. There is no apparent reason, however, why injuries greater than those brought on by repeated or prolonged flooding for frost injury of bogs that are dry-raked, should be incurred if certain precautions are observed.

The first precaution in water-raking is to avoid holding water on the

berries for a long period. This is particularly true of most Wisconsin bogs, as the oxygen content of the flooding water is low. A flooding period of 5 or 6 hours, or less if possible, is desirable. For this reason small flooding sections should be arranged. During the day, except in cloudy weather, injury is less apt to occur on account of the photosynthetic activity of the submerged vines. When there is danger of frost, the water may be held longer on account of the lower respiration rate of the cranberries, the reduction in the rate of oxidation of organic matter, and the increased capacity of the water for oxygen.

After picking, the conditions affecting the keeping quality of water-raked berries are the same as for dry-raked, and the recommendations of Shear and associates (4) should be carefully followed.

CONCLUSIONS

1. Storage tests indicate a superiority in the keeping quality of water-raked berries.

2. The spoilage of water-raked berries is due to two causes: fungous rots and smothering. Injury from smothering as a result of flooding is apt to occur in Wisconsin marshes on account of the low oxygen content of the flooding water.

3. Differences were observed in the keeping quality of different varieties of berries.

4. The age of the berries at the time of flooding is a factor in determining the degree of injury. Berries flooded before they are fully colored are more seriously injured than those flooded when fully colored.

5. The rate and completeness of drying affect the keeping quality by their influence on the extent of infection by rot-producing fungi. Quick and thorough drying is essential.

6. The possibilities of injury by water-raking are greater than in dry-raking. Water-raking may be done without serious injury if certain precautions are observed.

7. After picking, water-raked berries should be handled and stored with the same care given to dry-raked berries.

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LITERATURE CITED

1. **Bergman, H. F.** The effect of cloudiness on the oxygen content of water and its significance in cranberry culture. *Amer. Jour. Bot.* 8: 50-58. 1921.
2. **Franklin, H. J.** Report of the cranberry substation for 1916. *Mass. Agr. Exp. Sta. Bull.* 180. 1917.
3. **Hill, G. R., Jr.** Respiration of fruits and growing plant tissues in certain gases, with reference to ventilation and fruit storage. *Cornell Agr. Exp. Sta. Bull.* 330. 1913.
4. **Shear, C. L., Stevens, N. E., Wilcox, R. B., and Rudolph, B. A.** Spoilage of cranberries after harvest. *U. S. Dept. Agr. Bull.* 714. 1911.